

# **Recommended Program for North Carolina State Energy Code Compliance Study**

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# North Carolina Energy Code Compliance Study

## Background / Objective

New construction activity in North Carolina has been significant for the past several years. The table below lists the total number of new permits issued and the total valuation for 1998<sup>1</sup>. Activity in the first six months of 1999 continues this same trend.

1998 New Construction Activity in North Carolina		
<i>Building Type</i>	<i>Permits Issued</i>	<i>Property Valuation</i>
<b>Residential One/Two-Family</b>	61,319	\$7.25 Billion
<b>Commercial</b>	20,540	\$3.44 Billion
<b>Multi-family Units</b>	18,296	\$0.84 Billion

The North Carolina residential sector energy code is based on the 1995 Model Energy Code (MEC). The residential energy code applies to all new one- and two-family dwellings.

The commercial sector energy code is the *North Carolina State Building Code, Volume X – Energy*. The provisions of the code provide minimum standards for energy conservation. It is based on the codified version of ASHRAE/IES 90.1-1989 and applies to new multi-family residential (excludes new one- and two-family dwellings) and new commercial buildings. Commercial buildings include, but are not limited to occupancies for assembly, business, education, institutions, merchants, and storage. It does not apply to buildings intended primarily for manufacturing or commercial/industrial processing, buildings with a peak space conditioning energy use less than 3.5 Btu/hr/ft<sup>2</sup>, or buildings less than 100 ft<sup>2</sup> gross floor area.

Successful energy code implementation is a multi-faceted process: 1) code officials must have an adequate understanding of the code requirements to incorporate them into compliance checking activities; 2) design professionals and builders must have an adequate understanding of the code requirements to ensure they design buildings that comply with the code; 3) builders must actually construct their buildings to comply with the code requirements, and 4) code officials must verify that new buildings do comply with the code and that any deviations from the code are corrected.

This study focuses on the second and third steps in the above process – namely verifying that buildings are designed and built to comply with the energy code requirements.

The goal of the recommended program is to collect sufficient information to describe construction characteristics and practices related to energy efficiency in new residential and non-residential construction in a representative sample of North Carolina city and county code jurisdictions. A review and assessment of all permits issued in all jurisdictions would be cost-prohibitive, as there are 100 county jurisdictions and 153 municipal jurisdictions in North Carolina. Therefore, the recommended approach

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<sup>1</sup> Source: North Carolina Department of Labor (<http://www.dol.state.nc.us/stats/const.htm>)

is based on a random sampling process of new construction permits yielding results that are statistically significant and applicable to the entire state. The focus of the sampling will emphasize the most active jurisdictions, but not to the exclusion of the smaller, less active jurisdictions so as not to bias the results. The distribution of construction activity in North Carolina serving as the basis for developing the sample frame is based on a review of 1998 new construction permits. It is assumed that the relative geographical distribution of construction activity will not change significantly between 1998 and when this code compliance program is implemented. If for some reason it does, the selection of the most active jurisdictions will need to be revisited.

Two software tools are available to assist in the activity by automating the code compliance process – MECcheck™ and COMcheck™. MECcheck can be used in states such as North Carolina that require the MEC as their energy code for residential buildings. Additional information on these two software tools is presented later in the document.

The recommended work plan presented in this document is not intended to be the final word on the methodology to be used. Rather it offers some guidelines to be followed by North Carolina to ensure that the final results are statistically valid and meaningful. It is expected that those who will be responsible for implementing this study will include their experiences in the process.

## Scope

The recommended study will likely have three stages:

1. Construction Activity Review: The purpose of this review is to determine current activity in new residential and non-residential construction in the state of North Carolina, on a county-by-county basis. This information is critical to implementing the sampling design strategy and maintaining statistical integrity of the sample selection. New commercial construction data suitable for this process is available from F.W. Dodge (see Appendix A for data examples). Residential construction activity is available from the North Carolina Department of Labor website (<http://www.dol.state.nc.us/stats/const.htm>).
1. Code Compliance Verification – Plan Review: The purpose of this activity is to compare the building permit/plans for compliance to the requirement of the energy code. Focus will be on the most active jurisdictions to optimize the use of available resources, but some sampling will be necessary in small, low-activity jurisdictions so as not to bias the sample. Including the small jurisdictions is necessary to improve representation and identify if there are special problems with smaller jurisdictions. The MECcheck and COMcheck-EZ software tools can be used as part of the plan review to determine if the designed building meets the energy code.
1. Code Compliance Verification – Field Audit (optional): In this optional phase, for each jurisdiction sampled, a random sample of the buildings evaluated in the Plan Review phase will be selected for an in depth field inspection. The purpose of this activity is to compare the “as built” building to the permit/plan information. Additional information not available from the permit/plans and specifications will be collected.

## Recommended Energy Code Compliance Study Work Plan

### *Residential Sector*

The North Carolina residential sector energy code is based on the 1995 Model Energy Code (MEC). The residential energy code applies to all new detached one and two-family dwellings.

### **Residential Construction Activity**

A total of 61,319 new single-family housing permits were issued statewide in 1998. Twenty-nine of the 100 North Carolina counties had 500 or more issued permits. This accounted for 80% of the housing activity. Wake County (9059 permits) was the most active county, followed by Mecklenburg (8648), Guilford (3469), Union (2330), and Forsyth (1922). These five counties accounted for 42% of the single-family housing permits issued. At the other end of the spectrum, 24 counties had less than 100 new housing permits each, accounting for less than 2% of the total activity.

Table 1 shows the 1998 new residential construction activity by county/city.

### **Residential Sample Design**

The sample design for the residential sector should be based on a random sample of current new construction permits in North Carolina to ensure that the results are representative of the entire state. A two-step random sample selection process should be used to identify new homes for each level of inspection. At each step, the sample size is a progressively smaller, though random, sample of the previous sample.

A minimum of 288 homes will need to be reviewed to describe a representative sample of new construction. These homes are to be selected at random from the current set of new construction in the most active county/city jurisdictions. For this purpose, we have identified the top 37 counties and 11 cities representing 80% of the total population of permits issued. The targeted number of permits to be selected for review in each of these jurisdictions is shown in the sample frame in Table 2. In addition, another 30 homes should be selected at random from the remaining county/city jurisdictions to provide a sample of construction activity in the smaller, less active jurisdictions so as not to bias the results in favor of the more active jurisdictions. These approximately 308 homes should be subjected to a full plan review. Of these, a subset of approximately one-third of the plan review homes should be selected for the field inspection. These too should be selected at random.

## **Commercial Sector**

The commercial sector energy code provides minimum standards for energy conservation. It applies to new multi-family residential (excludes new one- and two-family dwellings) and new commercial buildings, including but not limited to occupancies for assembly, business, education, institutions, merchants, and storage. This section describes the sample recommended plan for the commercial sector. The plan for the multi-family sector follows in the next section.

### **Commercial Construction Activity**

In 1998, 20,540 new permits were issued for new commercial construction. Just over 80% of the activity was in 36 counties, and 50 counties had 90% of the activity. Eleven counties had 500 or more new permits issued, accounting for 48% of the activity. The top five counties were Mecklenburg (2230 permits issued), Wake (1362), Forsyth (970), New Hanover (933), and Iredell (856), accounting for 31% of the new construction activity. Six counties had no permits issued in 1998.

Table 3 shows distribution of new construction permits issued in 1998 for North Carolina counties and selected cities, sorted in order of most active to least active.

### **Commercial Sample Design**

The recommended approach in the commercial sector is based on a stratified random sample. Because of the expected large variance in new commercial construction characteristics, it will be advantageous to group the buildings into relatively homogeneous classes based on building size. This will reduce the variance among the individual buildings within each group and reduce the sample size necessary to characterize the entire commercial sector. Suggested ranges of building sizes for each group are:

Group 1 – less than 50,000 ft<sup>2</sup>,

Group 2 – 50,000 to 150,000 ft<sup>2</sup>,

Group 3 – greater than 150,000 ft<sup>2</sup>.

A stratified random sample design approach suggests that a target sample size of approximately 75 buildings, equally divided among the above three building size groups would be adequate to ensure that the sample drawn is representative of the entire population of new commercial construction in North Carolina. Because of the high likelihood of non-participation by potential designers/builders, an additional sample of 25 buildings should be selected to ensure that the final target of 75 randomly selected buildings is reached. The building sample is to be selected from the most active counties/county jurisdictions based on the current year's construction activity.

Although the commercial buildings will be selected for participation based on their size, the buildings selected need to be categorized as to building type. Suggested categories include: Office, Retail, Grocery, Restaurants, Warehouse, Educational, Assembly, Institutions, Lodging, Health Care, and Other. An example of the final sample frame for the commercial sector is shown in Table 4.

In order to develop the stratified sample design, additional data on the building type and size will need to be obtained. One source for this information would be the F.W. Dodge database for North Carolina.

### **Multi-family Sector**

For the purposes of this assessment, multi-family housing consists of two categories. The first is low-rise residential buildings three stories or less in height (excluding detached one and two family dwellings). The second category consists of high-rise residential structures.

#### **Multi-family Construction Activity**

A total of 18,296 new multi-family units were permitted in 1998. Approximately 80% of these were built in 12 counties. Twenty-seven counties had no new multifamily housing starts and an additional 18 counties had less than 10 units permitted. The top five counties, comprising 58% of the new multi-family units, are Mecklenburg (4206 units), Wake (3409), Guilford (1035), Durham (991) and Forsyth (915).

The MECcheck and COMcheck-EZ tools described above can be used to determine code compliance for low-rise residential and high-rise residential buildings, respectively.

Table 5 shows the distribution of multi-family units permitted in 1998 in each county and selected cities.

#### **Multi-family Sample Design**

The multi-family sample design should be similar to the commercial sample design process. Again, it needs to be a stratified random sample based on the number of individual units in each building, using information from a new construction database, such as that available from F.W. Dodge. A recommended grouping would be as follows:

Group 1 – 3-4 units, single story

Group 2 – low-rise residential, 4 units or more, up to 3 stories

Group 3 – high-rise residential, 4 stories or more

As with the commercial sample, a stratified random sample design suggests that a target sample size of approximately 75 buildings, equally divided among the above three building size groups, would be adequate to ensure that the sample drawn is representative of the entire population of new multi-family construction in North Carolina. Because of the high likelihood of non-participation by potential designers/builders, an additional sample of 25 buildings should be selected to ensure that the final target of 75 randomly selected buildings is reached. The building sample is to be selected from the most active counties/county jurisdictions based on the current year's construction activity.

A sample data frame is shown in Table 6.

## Steps in Code Compliance Process

The steps listed below apply to any of the three building sectors. Tier 1 activity is required for all three; Tier 2 is optional depending on the final level of verification desired by North Carolina and on available resources to perform the work.

### **Tier 1: Are residential and commercial buildings being designed for energy efficiency?**

- Determine the basis for selecting jurisdictions (i.e., areas of highest construction activity; rural or urban; thermal zone; geography; targeted areas) and identify targeted jurisdictions from the 100 counties and 150 municipalities<sup>2</sup>.
- Contact each of the candidate jurisdictions to: 1) identify those performing pre-construction plan review; 2) verify that they require and collect construction plans and Appendix J (Prescriptive Compliance Worksheet) for residential buildings and Appendix B (Building Code Summary for all Commercial Projects) for commercial buildings submitted as part of the permit application; 3) determine if they have accepted *MECcheck* and/or *COMcheck-EZ* outputs as demonstrating energy code compliance; and 4) determine if they are willing share the application data.
- Arrange visits to jurisdictional offices; collect and enter data from Appendix J or B into a database for the buildings selected at random according the sample design criteria.
- Compare the data against the appropriate energy code criteria.
- Compare data against reported practices in the NAHB construction data books.

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<sup>2</sup> This plan offers one approach to selecting the target jurisdictions. Other approaches are possible, depending on the level of resources available to commit to the effort.

- Enter data into MEC*check* or COM*check* software as a reference to national standards (percentage above or below).

## **Tier 2: Are residential and commercial buildings being constructed according to plans (Optional)?**

- Compare plans submitted with permit application to actual construction. Visit selected construction sites to determine whether construction is according to plans.

## **Available Software Tools for Code Compliance Verification**

The Department of Energy supports energy codes by helping with their development, and by providing tools and resources that make the codes easier to use. These materials have been developed to simplify and clarify building energy code requirements. The materials include easy-to-use Windows™ software and compliance guides, which provide a simple, prescriptive method for showing compliance with envelope, lighting, and mechanical energy code requirements. Forms and checklists are included for documenting compliance. Two of these products that have direct application to this North Carolina study are highlighted in the sections that follow.

### **MEC*check*™**

MEC*check* materials make it fast and easy for the user to determine whether new homes and additions meet the requirements of the MEC. The user can use MEC*check* to quickly determine if a low-rise residence meets the MEC.

The MEC*check* materials offer three simple ways to demonstrate compliance with the MEC. The **prescriptive approach**, the simplest of the three approaches, allows the user to select from various combinations of energy conservation measures based on "climate zone" location. Each combination or "package" specifies insulation levels, glazing areas, glazing U-values (thermal performance), and heating and cooling equipment efficiency. By locating the correct climate zone and looking up the appropriate table of packages, the user can ensure the project meets one of the packages listed for that zone.

The **trade-off worksheet approach** enables the user to vary insulation levels in the ceiling, wall, floor, basement wall, slab-edge and crawl space; glazing and door areas; and glazing and door U-values. Based on the proposed plans and specifications, the user enters simple information on a MEC*check* worksheet then manually calculates a total UA-value for the project. By comparing the project's UA-value to the value required for the climate zone, the user can determine if the project meets the MEC requirements. If the project does not meet the requirements, the user can use the worksheet to examine a different combination of insulation levels, window or door products and areas for compliance.

The MEC*check* **software approach** does the same calculations as the trade-off worksheet but automates the procedure using a computer. Special features allow the user to trade off heating and air conditioning equipment efficiencies, as well as windows and insulation. MEC*check* software automates calculations needed to determine compliance with the MEC.

Additional information on MEC*check* and instructions for downloading a copy of the software can be found on the U.S. Department of Energy's Building Standards and Guidelines Program (BSGP) web site at [www.energycodes.org](http://www.energycodes.org).

### **COMcheck-EZ<sup>TM</sup> and COMcheck-Plus<sup>TM</sup>**

Two software tools are available to assist in the evaluation of commercial building code compliance. *COMcheck-EZ* focuses on code requirements that apply to most small or simple commercial buildings and offers a streamlined process for demonstrating code-equivalent levels of energy efficiency. *COMcheck-EZ* can be used with most commercial energy codes based on ASHRAE/IES Standard 90.1-1989 (Energy Code for Commercial and High-Rise Residential Buildings). The printed *COMcheck-EZ* guides offer a simple prescriptive method, while the *COMcheck-EZ* software offers limited performance tradeoffs within the envelope and lighting sections.

*COMcheck-EZ* offers an easy-to-understand process for demonstrating compliance with all commercial energy code requirements for envelope, lighting, and mechanical systems. It eliminates calculation tasks other than determining square footages and requires no specialized technical knowledge of commercial codes. When applied to simple buildings, it is self-contained, requiring no additional resources or reference books.

*COMcheck-Plus* is a new software tool developed by the U.S. Department of Energy's Building Standards and Guidelines Program (BSGP), designed to simplify the process of demonstrating compliance with the commercial building energy code using whole-building performance methods. As initially released, *COMcheck-Plus* is suitable for use in jurisdictions with energy codes based on ASHRAE/IES Standard 90.1-1989, such as the ASHRAE 90.1 Code, the 1998 International Energy Conservation Code, and many state-developed energy codes. Buildings designed to comply with *COMcheck-Plus* can be "deemed to comply with" Standard 90.1. However, as with any code-related issue, the local jurisdiction has the final authority to determine whether *COMcheck-Plus* results will be accepted as adequate demonstration of compliance.

*COMcheck-Plus* implements the whole-building performance option in Standard 90.1, which is known as the Energy Cost Budget (ECB) Method in Standard 90.1. The *COMcheck-EZ* product is designed to make the first two compliance options as easy to use as possible.

Additional information on *COMcheck-EZ* and *COMcheck-Plus* and instructions for downloading the software can be found on the U.S. Department of Energy's Building Standards and Guidelines Program (BSGP) web site at [www.energycodes.org](http://www.energycodes.org).

## **Conclusion**

This document describes a recommended approach that is intended to provide guidance to North Carolina in designing a code compliance study that would yield results that are statistically significant and applicable to the entire state. The goal of the study is to collect sufficient information to describe current practice related to energy efficiency design and construction in new residential and non-residential buildings. The study, as envisioned, has three stages: (1) construction activity review and final sample plan development; (2) building permit review and determination of code compliance of the "as designed" building for a random sample of new construction; and (3) an optional field audit of a random sample of buildings at the plan review stage currently under construction to determine if the "as built" buildings agree with the "as designed" building and if they comply with the energy code.

To achieve the plan goals, the sample design must adhere to a few key principles:

- For residential sector, a simple random sample.
- For the commercial sector, a stratified random sample based on building size.
- For the multi-family sector, a stratified random sample based on building type.
- Focus the sampling on the most active jurisdictions with a sample from the smaller, less active jurisdictions so as not to bias the results.
- Keep the sample population as broadly representative as possible.
- Keep the sample of sufficient size to allow the natural variance within major building components (such as area and overall insulation levels) to be samples.
- Maintain statistical purity to allow extrapolation across the entire population.
- Keep the sample selection an unbiased sample, not self-selecting.

The U.S. Department of Energy's (DOE) Building Standards and Guidelines Program (BSGP) is committed to providing states and local jurisdictions with direct technical assistance to support their efforts to adopt, upgrade, implement, and enforce their building energy codes. Additional DOE support of North Carolina's energy code program could be available if requested.

**Table 1. Distribution by county and city of new single-family housing permits issued in 1998.**

**Residential Construction in North Carolina Counties  
January – December 1998**

COUNTY NAME	JURISDICTION	SINGLE FAMILY UNITS	Percent Total	Cummul. Percent	THERMAL ZONE
MECKLENBURG	County	5,696	9.3%	9.3%	7
WAKE	County	4,603	7.5%	16.8%	7
MECKLENBURG	CHARLOTTE	2,952	4.8%	21.6%	7
WAKE	RALEIGH	2,915	4.8%	26.4%	7
UNION	County	2,066	3.4%	29.7%	7
NEW HANOVER	WILMINGTON	1,795	2.9%	32.7%	6
JOHNSTON	County	1,605	2.6%	35.3%	7
DURHAM	DURHAM	1,508	2.5%	37.7%	8
GUILFORD	County	1,499	2.4%	40.2%	8
WAKE	CARY	1,390	2.3%	42.4%	7
IREDELL	County	1,356	2.2%	44.7%	8
FORSYTH	County	1,133	1.8%	46.5%	8
GUILFORD	GREENSBORO	1,132	1.8%	48.4%	8
BRUNSWICK	County	1,051	1.7%	50.1%	6
CUMBERLAND	County	949	1.5%	51.6%	7
CABARRUS	CONCORD	920	1.5%	53.1%	7
GUILFORD	HIGH POINT	838	1.4%	54.5%	8
FORSYTH	WINSTON-SALEM	789	1.3%	55.8%	8
MOORE	County	757	1.2%	57.0%	7
BUNCOMBE	County	754	1.2%	58.2%	9
HENDERSON	County	700	1.1%	59.4%	9
CATAWBA	County	699	1.1%	60.5%	8
DARE	County	698	1.1%	61.7%	6
GASTON	County	681	1.1%	62.8%	7
DAVIDSON	County	650	1.1%	63.8%	8
CABARRUS	County	601	1.0%	64.8%	7
HARNETT	County	598	1.0%	65.8%	7
ONSLOW	County	569	0.9%	66.7%	6
ALAMANCE	County	546	0.9%	67.6%	8
ORANGE	County	529	0.9%	68.5%	8
RANDOLPH	County	519	0.8%	69.3%	8
LINCOLN	County	507	0.8%	70.1%	7
CRAVEN	County	502	0.8%	71.0%	6
ROWAN	County	485	0.8%	71.7%	7
CARTERET	County	472	0.8%	72.5%	6

CHATHAM	County	457	0.7%	73.3%	8
PITT	GREENVILLE	416	0.7%	73.9%	7
MACON	County	387	0.6%	74.6%	9
HOKE	County	383	0.6%	75.2%	7
JACKSON	County	383	0.6%	75.8%	9
CURRITUCK	County	376	0.6%	76.4%	7
ORANGE	CHAPEL HILL	362	0.6%	77.0%	8
WATAUGA	County	359	0.6%	77.6%	11
HAYWOOD	County	357	0.6%	78.2%	9
PITT	County	354	0.6%	78.8%	7
NASH	County	353	0.6%	79.3%	7
FRANKLIN	County	347	0.6%	79.9%	8
TRANSYLVANIA	County	321	0.5%	80.4%	9
BUNCOMBE	ASHEVILLE	318	0.5%	80.9%	9
CALDWELL	County	297	0.5%	81.4%	8
CLEVELAND	County	293	0.5%	81.9%	7
RICHMOND	County	292	0.5%	82.4%	7
WILSON	WILSON	287	0.5%	82.9%	7
DAVIE	County	273	0.4%	83.3%	8
CHEROKEE	County	271	0.4%	83.7%	9
SURRY	County	271	0.4%	84.2%	9
RUTHERFORD	County	269	0.4%	84.6%	7
WILKES	County	266	0.4%	85.1%	9
UNION	MONROE	264	0.4%	85.5%	7
DURHAM	County	255	0.4%	85.9%	8
CUMBERLAND	FAYETTEVILLE	251	0.4%	86.3%	7
WAYNE	County	251	0.4%	86.7%	7
BURKE	County	246	0.4%	87.1%	8
CATAWBA	HICKORY	246	0.4%	87.5%	8
ROCKINGHAM	County	243	0.4%	87.9%	8
ASHE	County	239	0.4%	88.3%	11
ONslow	JACKSONVILLE	237	0.4%	88.7%	6
GRANVILLE	County	224	0.4%	89.1%	8
STANLY	County	222	0.4%	89.4%	7
CABARRUS	KANNAPOLIS	213	0.3%	89.8%	7
DAVIDSON	THOMASVILLE	206	0.3%	90.1%	8
PENDER	County	205	0.3%	90.4%	6
STOKES	County	196	0.3%	90.8%	9
GASTON	GASTONIA	176	0.3%	91.0%	7
SAMPSON	County	171	0.3%	91.3%	6
ALAMANCE	BURLINGTON	167	0.3%	91.6%	8
NASH	ROCKY MOUNT	166	0.3%	91.9%	7
BEAUFORT	County	165	0.3%	92.1%	6

ROWAN	SALISBURY	156	0.3%	92.4%	7
ALLEGHANY	County	155	0.3%	92.6%	11
YADKIN	County	155	0.3%	92.9%	8
PERSON	County	153	0.2%	93.1%	8
ROBESON	County	153	0.2%	93.4%	7
WAKE	GARNER	151	0.2%	93.6%	7
CLAY	County	148	0.2%	93.9%	9
CRAVEN	NEW BERN	144	0.2%	94.1%	6
ALEXANDER	County	141	0.2%	94.4%	8
YANCEY	County	136	0.2%	94.6%	11
MADISON	County	132	0.2%	94.8%	9
POLK	County	128	0.2%	95.0%	7
MCDOWELL	County	124	0.2%	95.2%	8
LEE	County	122	0.2%	95.4%	7
DUPLIN	County	118	0.2%	95.6%	6
SWAIN	County	114	0.2%	95.8%	9
AVERY	County	113	0.2%	96.0%	11
LEE	SANFORD	111	0.2%	96.1%	8
MONTGOMERY	County	108	0.2%	96.3%	7
LENOIR	County	99	0.2%	96.5%	7
VANCE	HENDERSON	99	0.2%	96.6%	8
PASQUOTANK	County	98	0.2%	96.8%	7
WAYNE	GOLDSBORO	89	0.1%	96.9%	7
WILSON	County	84	0.1%	97.1%	7
CAMDEN	County	81	0.1%	97.2%	7
BLADEN	County	77	0.1%	97.3%	6
IREDELL	STATESVILLE	74	0.1%	97.5%	8
WARREN	County	72	0.1%	97.6%	8
CASWELL	County	70	0.1%	97.7%	8
NORTHAMPTON	County	70	0.1%	97.8%	7
CRAVEN	HAVELOCK	63	0.1%	97.9%	6
PAMLICO	County	63	0.1%	98.0%	6
PASQUOTANK	ELIZABETH CITY	62	0.1%	98.1%	7
MITCHELL	County	59	0.1%	98.2%	11
GRAHAM	County	58	0.1%	98.3%	9
SCOTLAND	County	58	0.1%	98.4%	7
PERQUIMANS	County	56	0.1%	98.5%	7
COLUMBUS	County	54	0.1%	98.6%	6
CLEVELAND	SHELBY	52	0.1%	98.7%	7
CALDWELL	LENOIR	49	0.1%	98.7%	8
DAVIDSON	LEXINGTON	49	0.1%	98.8%	8
RANDOLPH	ASHEBORO	49	0.1%	98.9%	8
HALIFAX	County	47	0.1%	99.0%	7
ROBESON	LUMBERTON	47	0.1%	99.1%	7
SCOTLAND	LAURINBURG	47	0.1%	99.1%	7
ANSON	County	42	0.1%	99.2%	7

MARTIN	County	41	0.1%	99.3%	7
EDGECOMBE	County	40	0.1%	99.3%	7
ROCKINGHAM	EDEN	35	0.1%	99.4%	8
GREENE	County	34	0.1%	99.4%	7
LENOIR	KINSTON	34	0.1%	99.5%	7
BERTIE	County	33	0.1%	99.6%	7
BURKE	MORGANTON	32	0.1%	99.6%	8
HERTFORD	County	31	0.1%	99.7%	7
ROCKINGHAM	REIDSVILLE	31	0.1%	99.7%	8
HALIFAX	ROANOKE RAPIDS	27	0.0%	99.8%	7
STANLY	ALBEMARLE	25	0.0%	99.8%	7
CHOWAN	County	24	0.0%	99.8%	7
WATAUGA	BOONE	22	0.0%	99.9%	11
GATES	County	20	0.0%	99.9%	8
HYDE	County	16	0.0%	99.9%	6
JONES	County	13	0.0%	99.9%	6
WASHINGTON	County	13	0.0%	100.0%	7
EDGECOMBE	TARBORO	12	0.0%	100.0%	7
TYRRELL	County	7	0.0%	100.0%	6
NEW HANOVER	County	0	0.0%	100.0%	6
VANCE	County	0	0.0%	100.0%	8

Table 2. Residential Sample Frame.

**Residential Construction in North Carolina Counties  
January – December 1998**

COUNTY NAME	JURISDICTION (County / CITY)	SINGLE FAMILY UNITS	Percent Total	Plan Inspection	Field Inspection	THERMAL ZONE
MECKLENBURG	County	5,696	9.3%	33	11	7
WAKE	County	4,603	7.5%	27	9	7
MECKLENBURG	CHARLOTTE	2,952	4.8%	17	6	7
WAKE	RALEIGH	2,915	4.8%	17	6	7
UNION	County	2,066	3.4%	12	4	7
NEW HANOVER	WILMINGTON	1,795	2.9%	10	3	6
JOHNSTON	County	1,605	2.6%	9	3	7
DURHAM	DURHAM	1,508	2.5%	9	3	8
GUILFORD	County	1,499	2.4%	9	3	8
WAKE	CARY	1,390	2.3%	8	3	7
IREDELL	County	1,356	2.2%	8	3	8
FORSYTH	County	1,133	1.8%	7	2	8
GUILFORD	GREENSBORO	1,132	1.8%	7	2	8
BRUNSWICK	County	1,051	1.7%	6	2	6
CUMBERLAND	County	949	1.5%	6	2	7
CABARRUS	CONCORD	920	1.5%	5	2	7
GUILFORD	HIGH POINT	838	1.4%	5	2	8
FORSYTH	WINSTON-SALEM	789	1.3%	5	2	8
MOORE	County	757	1.2%	4	1	7
BUNCOMBE	County	754	1.2%	4	1	9
HENDERSON	County	700	1.1%	4	1	9
CATAWBA	County	699	1.1%	4	1	8
DARE	County	698	1.1%	4	1	6
GASTON	County	681	1.1%	4	1	7
DAVIDSON	County	650	1.1%	4	1	8
CABARRUS	County	601	1.0%	4	1	7
HARNETT	County	598	1.0%	3	1	7
ONSLOW	County	569	0.9%	3	1	6
ALAMANCE	County	546	0.9%	3	1	8
ORANGE	County	529	0.9%	3	1	8
RANDOLPH	County	519	0.8%	3	1	8
LINCOLN	County	507	0.8%	3	1	7
CRAVEN	County	502	0.8%	3	1	6
ROWAN	County	485	0.8%	3	1	7
CARTERET	County	472	0.8%	3	1	6

<b>CHATHAM</b>	<b>County</b>	457	0.7%	3	1	8
<b>PITT</b>	<b>GREENVILLE</b>	416	0.7%	2	1	7
<b>MACON</b>	<b>County</b>	387	0.6%	2	1	9
<b>HOKE</b>	<b>County</b>	383	0.6%	2	1	7
<b>JACKSON</b>	<b>County</b>	383	0.6%	2	1	9
<b>CURRITUCK</b>	<b>County</b>	376	0.6%	2	1	7
<b>ORANGE</b>	<b>CHAPEL HILL</b>	362	0.6%	2	1	8
<b>WATAUGA</b>	<b>County</b>	359	0.6%	2	1	11
<b>HAYWOOD</b>	<b>County</b>	357	0.6%	2	1	9
<b>PITT</b>	<b>County</b>	354	0.6%	2	1	7
<b>NASH</b>	<b>County</b>	353	0.6%	2	1	7
<b>FRANKLIN</b>	<b>County</b>	347	0.6%	2	1	8
<b>TRANSYLVANIA</b>	<b>County</b>	321	0.5%	2	1	9
<b>TOTALS</b>		<b>49,319</b>	<b>80.4%</b>	<b>288</b>	<b>95</b>	
	<b>Counties = 37</b>					
	<b>Cities = 11</b>					

**Table 3. Distribution by county and city of new commercial permits issued in 1998.**

**COMMERCIAL CONSTRUCTION IN SELECTED NORTH CAROLINA COUNTIES**  
**January – December 1998**

COUNTY NAME	JURISDICTION	NON-RES UNITS	Percent Total	Cummul. Percent	THERMAL ZONE
MECKLENBURG	CHARLOTTE	1,616	7.8%	7.8%	V
NEW HANOVER	WILMINGTON	936	4.5%	12.2%	II
IREDELL	County	775	3.7%	16.0%	IV
FORSYTH	WINSTON-SALEM	645	3.1%	19.1%	IV
MECKLENBURG	County	614	2.9%	22.0%	V
ROWAN	County	525	2.5%	24.5%	IV
DURHAM	DURHAM	494	2.4%	26.9%	IV
CATAWBA	County	481	2.3%	29.2%	V
WAKE	RALEIGH	433	2.1%	31.3%	III
WAKE	County	414	2.0%	33.3%	III
HENDERSON	County	407	2.0%	35.2%	VI
JOHNSTON	County	403	1.9%	37.2%	III
WAKE	CARY	381	1.8%	39.0%	III
CHATHAM	County	367	1.8%	40.8%	IV
CUMBERLAND	FAYETTEVILLE	344	1.7%	42.4%	III
FORSYTH	County	325	1.6%	44.0%	IV
PITT	GREENVILLE	319	1.5%	45.5%	III
NASH	ROCKY MOUNT	307	1.5%	47.0%	III
ALAMANCE	BURLINGTON	301	1.4%	48.4%	IV
UNION	County	299	1.4%	49.9%	V
GUILFORD	GREENSBORO	298	1.4%	51.3%	IV
RANDOLPH	County	284	1.4%	52.6%	IV
RUTHERFORD	County	245	1.2%	53.8%	VI
CABARRUS	CONCORD	242	1.2%	55.0%	V
BRUNSWICK	County	230	1.1%	56.1%	II
VANCE	County	226	1.1%	57.2%	IV
VANCE	HENDERSON	226	1.1%	58.3%	IV
GUILFORD	County	220	1.1%	59.3%	IV
DAVIDSON	County	218	1.0%	60.4%	IV
NASH	County	212	1.0%	61.4%	III
ONSLOW	JACKSONVILLE	208	1.0%	62.4%	II
ROBESON	County	206	1.0%	63.4%	III
PITT	County	205	1.0%	64.3%	III
BUNCOMBE	ASHEVILLE	185	0.9%	65.2%	VI
GUILFORD	HIGH POINT	181	0.9%	66.1%	IV

SAMPSON	County	181	0.9%	67.0%	III
DARE	County	177	0.8%	67.8%	I
DUPLIN	County	168	0.8%	68.6%	III
HARNETT	County	161	0.8%	69.4%	III
GRANVILLE	County	153	0.7%	70.1%	IV
BUNCOMBE	County	146	0.7%	70.8%	VI
STANLY	County	145	0.7%	71.5%	V
CALDWELL	County	141	0.7%	72.2%	VI
ASHE	County	139	0.7%	72.9%	VII
HALIFAX	ROANOKE RAPIDS	137	0.7%	73.5%	IV
WAKE	GARNER	134	0.6%	74.2%	III
BURKE	County	129	0.6%	74.8%	VI
PENDER	County	127	0.6%	75.4%	II
MACON	County	123	0.6%	76.0%	VI
YADKIN	County	122	0.6%	76.6%	IV
CHEROKEE	County	120	0.6%	77.2%	VI
FRANKLIN	County	120	0.6%	77.7%	III
WATAUGA	County	118	0.6%	78.3%	VII
WAYNE	County	117	0.6%	78.9%	III
WILSON	WILSON	108	0.5%	79.4%	III
UNION	MONROE	105	0.5%	79.9%	V
JACKSON	County	101	0.5%	80.4%	VI
CRAVEN	NEW BERN	100	0.5%	80.9%	II
GASTON	GASTONIA	100	0.5%	81.3%	V
GASTON	County	99	0.5%	81.8%	V
LINCOLN	County	97	0.5%	82.3%	V
CLEVELAND	County	95	0.5%	82.7%	V
CURRITUCK	County	95	0.5%	83.2%	I
PASQUOTANK	ELIZABETH CITY	92	0.4%	83.6%	I
CRAVEN	HAVELOCK	90	0.4%	84.1%	II
WILSON	County	90	0.4%	84.5%	III
HALIFAX	County	89	0.4%	84.9%	IV
WILKES	County	88	0.4%	85.3%	IV
PERSON	County	87	0.4%	85.8%	IV
BLADEN	County	86	0.4%	86.2%	III
CASWELL	County	85	0.4%	86.6%	IV
DURHAM	County	85	0.4%	87.0%	IV
CLEVELAND	SHELBY	84	0.4%	87.4%	V
BEAUFORT	County	83	0.4%	87.8%	II
CABARRUS	KANNAPOLIS	82	0.4%	88.2%	V
POLK	County	82	0.4%	88.6%	VI
HERTFORD	County	81	0.4%	89.0%	IV
IREDELL	STATESVILLE	81	0.4%	89.4%	IV

LEE	SANFORD	81	0.4%	89.7%	III
CRAVEN	County	80	0.4%	90.1%	II
ALAMANCE	County	78	0.4%	90.5%	IV
ALEXANDER	County	78	0.4%	90.9%	IV
MCDOWELL	County	73	0.4%	91.2%	VI
MOORE	County	69	0.3%	91.6%	V
NORTHAMPTON	County	69	0.3%	91.9%	IV
CATAWBA	HICKORY	66	0.3%	92.2%	V
ROCKINGHAM	EDEN	66	0.3%	92.5%	IV
BURKE	MORGANTON	65	0.3%	92.8%	VI
ROWAN	SALISBURY	61	0.3%	93.1%	IV
DAVIDSON	THOMASVILLE	60	0.3%	93.4%	IV
BERTIE	County	58	0.3%	93.7%	IV
PASQUOTANK	County	58	0.3%	94.0%	I
ONslow	County	56	0.3%	94.2%	II
LEE	County	54	0.3%	94.5%	III
ALLEGHANY	County	52	0.2%	94.7%	VII
SURRY	County	50	0.2%	95.0%	IV
AVERY	County	48	0.2%	95.2%	VII
STANLY	ALBEMARLE	47	0.2%	95.4%	V
TRANSYLVANIA	County	47	0.2%	95.7%	VI
ROBESON	LUMBERTON	44	0.2%	95.9%	III
ROCKINGHAM	REIDSVILLE	44	0.2%	96.1%	IV
HAYWOOD	County	43	0.2%	96.3%	VI
GRAHAM	County	42	0.2%	96.5%	VI
MADISON	County	39	0.2%	96.7%	VII
EDGEcombe	TARBORO	38	0.2%	96.9%	III
RANDOLPH	ASHEBORO	38	0.2%	97.1%	IV
WAYNE	GOLDSBORO	38	0.2%	97.2%	III
CALDWELL	LENOIR	37	0.2%	97.4%	VI
DAVIE	County	37	0.2%	97.6%	IV
HYDE	County	37	0.2%	97.8%	I
MONTGOMERY	County	37	0.2%	97.9%	V
CHOWAN	County	36	0.2%	98.1%	I
DAVIDSON	LEXINGTON	35	0.2%	98.3%	IV
MARTIN	County	33	0.2%	98.4%	IV
PERQUIMANS	County	32	0.2%	98.6%	I
GREENE	County	27	0.1%	98.7%	III
LENOIR	KINSTON	27	0.1%	98.9%	III
WASHINGTON	County	27	0.1%	99.0%	I
ANSON	County	25	0.1%	99.1%	V
GATES	County	23	0.1%	99.2%	I
PAMLICO	County	22	0.1%	99.3%	II
WATAUGA	BOONE	20	0.1%	99.4%	VII
YANCEY	County	16	0.1%	99.5%	VI
CABARRUS	County	15	0.1%	99.6%	V

SWAIN	County	15	0.1%	99.6%	VI
EDGECOMBE	County	14	0.1%	99.7%	III
LENOIR	County	14	0.1%	99.8%	III
ORANGE	CHAPEL HILL	12	0.1%	99.8%	IV
JONES	County	8	0.0%	99.9%	II
MITCHELL	County	8	0.0%	99.9%	VII
RICHMOND	County	8	0.0%	99.9%	V
CLAY	County	4	0.0%	100.0%	VI
COLUMBUS	County	4	0.0%	100.0%	III
CAMDEN	County	3	0.0%	100.0%	I
CARTERET	County	0	0.0%	100.0%	II
CUMBERLAND	County	0	0.0%	100.0%	III
HOKE	County	0	0.0%	100.0%	III
NEW HANOVER	County	0	0.0%	100.0%	II
ORANGE	County	0	0.0%	100.0%	IV
ROCKINGHAM	County	0	0.0%	100.0%	IV
SCOTLAND	County	0	0.0%	100.0%	III
SCOTLAND	LAURINBURG	0	0.0%	100.0%	III
STOKES	County	0	0.0%	100.0%	IV
TYRRELL	County	0	0.0%	100.0%	I
WARREN	County	0	0.0%	100.0%	IV

**Table 4. Sample frame design for the new commercial construction**

<b>Building Type</b>	<b>New Construction Total</b>	<b>% Total</b>	<b>Plan Inspection</b>	<b>Field Inspection</b>
<b>Office</b>	$N_1$	$P_1$		
<b>Retail</b>	$N_2$	$P_2$		
<b>Grocery</b>	$N_3$	$P_3$		
<b>Restaurant</b>	$N_4$	$P_4$		
<b>Warehouse</b>	$N_5$	$P_5$		
<b>School</b>	$N_6$	$P_6$		
<b>Assembly</b>	$N_7$	$P_7$		
<b>Institution</b>	$N_8$	$P_8$		
<b>Lodging</b>	$N_9$	$P_9$		
<b>Health</b>	$N_{10}$	$P_{10}$		
<b>Other</b>	$N_{11}$	$P_{11}$		
<b>Total</b>	$N_t$	100.0%	75	TBD

Table 5. Distribution by county and city of new multifamily units permitted in 1998.

**Multi-Family Construction in Selected North Carolina Counties  
January – December 1998**

COUNTY NAME	JURISDICTION	MULTI-FAMILY UNITS	Percent Total	Cummul. Percent	THERMAL ZONE
MECKLENBURG	CHARLOTTE	2,403	13.0%	13.0%	7
MECKLENBURG	County	1,803	9.8%	22.8%	7
WAKE	County	1,519	8.2%	31.1%	7
WAKE	RALEIGH	1,260	6.8%	37.9%	7
DURHAM	DURHAM	979	5.3%	43.2%	8
GUILFORD	GREENSBORO	961	5.2%	48.4%	8
NEW HANOVER	WILMINGTON	799	4.3%	52.8%	6
FORSYTH	County	749	4.1%	56.8%	8
CUMBERLAND	FAYETTEVILLE	635	3.4%	60.3%	7
WAKE	CARY	615	3.3%	63.6%	7
PITT	GREENVILLE	564	3.1%	66.7%	7
ALAMANCE	County	533	2.9%	69.6%	8
CATAWBA	HICKORY	500	2.7%	72.3%	8
ORANGE	CHAPEL HILL	337	1.8%	74.1%	8
ALAMANCE	BURLINGTON	325	1.8%	75.9%	8
IREDELL	STATESVILLE	255	1.4%	77.3%	8
CRAVEN	NEW BERN	186	1.0%	78.3%	7
BUNCOMBE	ASHEVILLE	177	1.0%	79.2%	9
GASTON	GASTONIA	174	0.9%	80.2%	7
ORANGE	County	172	0.9%	81.1%	8
IREDELL	County	167	0.9%	82.0%	8
FORSYTH	WINSTON-SALEM	166	0.9%	82.9%	8
ROWAN	County	154	0.8%	83.8%	7
CLEVELAND	SHELBY	148	0.8%	84.6%	7
UNION	MONROE	142	0.8%	85.3%	7
BUNCOMBE	County	134	0.7%	86.1%	9
BRUNSWICK	County	133	0.7%	86.8%	6
WILSON	WILSON	126	0.7%	87.5%	7
RANDOLPH	ASHEBORO	124	0.7%	88.1%	8
ROWAN	SALISBURY	116	0.6%	88.8%	7
CUMBERLAND	County	106	0.6%	89.4%	7
MOORE	County	105	0.6%	89.9%	7
RANDOLPH	County	100	0.5%	90.5%	8

GASTON	County	90	0.5%	91.0%	7
ONslow	JACKSONVILLE	84	0.5%	91.4%	6
HENDERSON	County	75	0.4%	91.8%	9
GUILFORD	County	74	0.4%	92.2%	8
CHATHAM	County	70	0.4%	92.6%	8
ROCKINGHAM	EDEN	70	0.4%	93.0%	8
ROBESON	LUMBERTON	67	0.4%	93.3%	7
JACKSON	County	60	0.3%	93.7%	9
CARTERET	County	58	0.3%	94.0%	6
JOHNSTON	County	58	0.3%	94.3%	7
DARE	County	50	0.3%	94.6%	6
LENOIR	KINSTON	48	0.3%	94.8%	7
HALIFAX	ROANOKE RAPIDS	46	0.2%	95.1%	7
NASH	County	41	0.2%	95.3%	7
WATAUGA	BOONE	40	0.2%	95.5%	11
HARNETT	County	37	0.2%	95.7%	7
PASQUOTANK	ELIZABETH CITY	36	0.2%	95.9%	7
PITT	County	34	0.2%	96.1%	7
WAYNE	GOLDSBORO	34	0.2%	96.3%	7
DAVIDSON	THOMASVILLE	32	0.2%	96.5%	8
SCOTLAND	LAURINBURG	31	0.2%	96.6%	7
BURKE	County	30	0.2%	96.8%	8
DUPLIN	County	26	0.1%	96.9%	6
LEE	SANFORD	26	0.1%	97.1%	8
LINCOLN	County	26	0.1%	97.2%	7
WATAUGA	County	26	0.1%	97.4%	11
ALLEGHANY	County	24	0.1%	97.5%	11
UNION	County	24	0.1%	97.6%	7
VANCE	HENDERSON	23	0.1%	97.7%	8
DAVIDSON	County	20	0.1%	97.8%	8
GRANVILLE	County	20	0.1%	98.0%	8
LENOIR	County	20	0.1%	98.1%	7
HERTFORD	County	19	0.1%	98.2%	7
CABARRUS	County	17	0.1%	98.3%	7
RUTHERFORD	County	17	0.1%	98.3%	7
BEAUFORT	County	16	0.1%	98.4%	6
CABARRUS	CONCORD	15	0.1%	98.5%	7
CURRITUCK	County	15	0.1%	98.6%	7
WAKE	GARNER	15	0.1%	98.7%	7
CLEVELAND	County	14	0.1%	98.8%	7
HYDE	County	14	0.1%	98.8%	6
ROCKINGHAM	REIDSVILLE	14	0.1%	98.9%	8
DURHAM	County	12	0.1%	99.0%	8

MCDOWELL	County	12	0.1%	99.0%	8
WAYNE	County	12	0.1%	99.1%	7
ROBESON	County	11	0.1%	99.2%	7
DAVIDSON	LEXINGTON	10	0.1%	99.2%	8
STANLY	ALBEMARLE	10	0.1%	99.3%	7
WARREN	County	10	0.1%	99.3%	8
ANSON	County	9	0.0%	99.4%	7
BURKE	MORGANTON	9	0.0%	99.4%	8
ALEXANDER	County	8	0.0%	99.5%	8
HAYWOOD	County	8	0.0%	99.5%	9
HOKE	County	8	0.0%	99.6%	7
NASH	ROCKY MOUNT	8	0.0%	99.6%	7
ONslow	County	8	0.0%	99.6%	6
SURRY	County	8	0.0%	99.7%	9
WILKES	County	8	0.0%	99.7%	9
CABARRUS	KANNAPOLIS	7	0.0%	99.8%	7
CALDWELL	LENOIR	6	0.0%	99.8%	8
PERQUIMANS	County	6	0.0%	99.8%	7
YADKIN	County	6	0.0%	99.9%	8
SCOTLAND	County	5	0.0%	99.9%	7
PERSON	County	4	0.0%	99.9%	8
YANCEY	County	4	0.0%	99.9%	11
STOKES	County	3	0.0%	100.0%	9
ASHE	County	2	0.0%	100.0%	11
BLADEN	County	2	0.0%	100.0%	6
PAMLICO	County	2	0.0%	100.0%	6
TYRRELL	County	2	0.0%	100.0%	6
POLK	County	1	0.0%	100.0%	7
AVERY	County	0	0.0%	100.0%	11
BERTIE	County	0	0.0%	100.0%	7
CALDWELL	County	0	0.0%	100.0%	8
CAMDEN	County	0	0.0%	100.0%	7
CASWELL	County	0	0.0%	100.0%	8
CATAWBA	County	0	0.0%	100.0%	8
CHEROKEE	County	0	0.0%	100.0%	9
CHOWAN	County	0	0.0%	100.0%	7
CLAY	County	0	0.0%	100.0%	9
COLUMBUS	County	0	0.0%	100.0%	6
CRAVEN	HAVELOCK	0	0.0%	100.0%	6
CRAVEN	County	0	0.0%	100.0%	6
DAVIE	County	0	0.0%	100.0%	8
EDGEcombe	TARBORO	0	0.0%	100.0%	7
EDGEcombe	County	0	0.0%	100.0%	7
FRANKLIN	County	0	0.0%	100.0%	8
GATES	County	0	0.0%	100.0%	8
GRAHAM	County	0	0.0%	100.0%	9

GREENE	County	0	0.0%	100.0%	7
GUILFORD	HIGH POINT	0	0.0%	100.0%	8
HALIFAX	County	0	0.0%	100.0%	7
JONES	County	0	0.0%	100.0%	6
LEE	County	0	0.0%	100.0%	7
MACON	County	0	0.0%	100.0%	9
MADISON	County	0	0.0%	100.0%	9
MARTIN	County	0	0.0%	100.0%	7
MITCHELL	County	0	0.0%	100.0%	11
MONTGOMERY	County	0	0.0%	100.0%	7
NEW HANOVER	County	0	0.0%	100.0%	6
NORTHAMPTON	County	0	0.0%	100.0%	7
PASQUOTANK	County	0	0.0%	100.0%	7
PENDER	County	0	0.0%	100.0%	6
RICHMOND	County	0	0.0%	100.0%	7
ROCKINGHAM	County	0	0.0%	100.0%	8
SAMPSON	County	0	0.0%	100.0%	6
STANLY	County	0	0.0%	100.0%	7
SWAIN	County	0	0.0%	100.0%	9
TRANSYLVANIA	County	0	0.0%	100.0%	9
VANCE	County	0	0.0%	100.0%	8
WASHINGTON	County	0	0.0%	100.0%	7
WILSON	County	0	0.0%	100.0%	7

**Table 6. Sample multi-family data frame.**

<b>Building Group</b>	<b>New Construction Total</b>	<b>% Total</b>	<b>Plan Inspection</b>	<b>Field Inspection</b>
<b>3-4 units, single story</b>	$N_1$	$P_1$		
<b>Low-rise residential, up to 3 story</b>	$N_2$	$P_2$		
<b>high rise residential, 4 story or more</b>	$N_3$	$P_3$		
<b>Total</b>	$N_t$	100.0%	75	TBD

## **APPENDIX A**

Sample FW Dodge data sets for commercial and residential construction activity